APPENDIX O - LASER AND DIRECTED ENERGY HAZARDS

1.1 - GENERAL

Laser rangefinders/designators used by both threat and friendly forces are sources of laser hazards within the combat environment. Laser emitters may be encountered almost anywhere on the battlefield, and they pose a serious threat to aircrews and acquisition/targeting sensors on the aircraft. Laser hazards can occur not only from a direct hit from a laser beam, but also from a reflected hit from a beam directed elsewhere. The laser light may be reflected from water, aircraft canopies or windshields, or other reflective surfaces. Injury can also result from reflection from unpolished objects such as a sand dune. The hazards to personnel and equipment from lasers depend largely on the radiation wavelength, the beam intensity, and the exposure time. The danger to personnel results from either direct or reflected exposure to radiation, which could ignite clothing or damage unprotected skin or eyes. Lasers can also adversely affect optical systems. Both direct-view (binoculars and weapon sights) and indirect (image conversion devices) optical systems can be damaged by the effects of far-, near-, and visible-infrared lasers.

1.2 - EFFECTS ON PERSONNEL

- If a visible light laser strikes an individual's eyes, the individual may experience flash blindness or other injury. The victim will feel nothing if the injury is minor. A common symptom is pain similar to that caused by a grain of dust in the eye. The victim may have difficulty seeing fine details and may experience disorientation or pain or see dots and streamers floating in his vision.
- Only the visible- and near-infrared light entering the eye will harm the retina. The eye is more vulnerable to damage at night since the iris is normally open wider than during the day. Laser effects on the eyes include flash blindness, minor and major retinal bums, and impaired night vision. The effect of flash blinding on vision is similar to the temporary effect of a flash bulb. The effects last from seconds to minutes and may leave colored spots in the eyes. Minor retinal burns can cause discomfort and interfere with vision and may not be immediately noticeable. Major retinal bums result in major damage to or loss of vision. The injuries involve bleeding inside the eye, immediate pain, and possible permanent loss of or impaired vision. Night vision acuity may be lost because of undetected damage. A laser attack that damaged the fovea, where most of the cones are located, might go unnoticed because rod cells are used for night vision. Foveal damage may affect vision sharpness and color interpretation. Normal cockpit tasks, obstacle avoidance, and the use of acquisition or targeting devices could become difficult or impossible.
- The use of magnifying optics in a laser environment can be extremely dangerous. The optics focus the beam to a much smaller area and concentrate the power of the beam. Binoculars, TSUs, TADS (direct-view optics), and handheld stabilized sights send more light into the eye. At tactical distances of 1 to 2 kilometers, exposure to lasers through unprotected optics (without filters) makes injury likely. However, the narrow field of view of optical systems and the small spot size reduce the likelihood that a laser beam will actually enter the system and damage the eye. Burns may result from reflected laser light focused on the retina of the eye.

1.3 - EFFECTS ON EQUIPMENT

1.3.1 - Effects on Direct-View Optics

- Direct-view optics are hard to damage with visible- and near-infrared lasers. These optics are designed to pass as much light as possible. If a laser is powerful enough or close enough, it may pit reticles, destroy protective filters, and crack lenses.
- Nonfiltered Optics. The optical device may not have the right filter in place when lased. In this case, the viewer may suffer severe eye damage long before the optical sight is damaged.
- Ordinary Optics. Far-infrared lasers do not penetrate ordinary optics. The energy is deposited on or in the lenses and windows. A far-infrared laser that is powerful or close enough can craze, crack, or shatter outside lenses or windows. Crazing results in a frosted or sandblasted appearance. A crack with no impact scar (like the scar from a rock on a windshield) may indicate laser damage.

1.3.2 - Effects on Indirect-View Optics

Image conversion devices, such as night vision devices and tracking systems on current weapon systems, are subject to damage from near-infrared and visible lasers. If the image converter is sensitive to light from the laser, the viewer will see a bright flash of light. Overloaded circuits may cause the system to lose power and then restart. If the damage to the tube is not severe, the display will reappear with dark spots or lines. If the tube is destroyed, the display will remain dark. The flash from the display may dazzle the operator briefly. However, the operator is completely protected from eye injury by such systems.

1.4 - PASSIVE COUNTERMEASURES

The most likely known laser threat is the Laser Rangefinder/Designator (LRF/D). Aircrews must be able to recognize the presence of LRF/D on the battlefield. Unfortunately, each device can come in many possible sizes and shapes. However, some reliable clues can help determine whether a device is a laser range finder/designator.

1.5 - LASER RANGEFINDERS/DESIGNATORS USED BY PERSONNEL

The size of an LRF/D can vary from the size of binoculars (handheld) to the size of an orange crate (mounted on a vehicle). Laser range finders/designators used by personnel are easily recognized.

1.6 - LASER RANGEFINDERS/DESIGNATORS USED ON VEHICLES

The LRF/D system mounted on a vehicle can be an integral part of the platform with very few, if any, discernible physical characteristics. This is true of an LRF/D mounted on a tank. The best way to determine whether an armored vehicle has an LRF/D is to know which vehicles are equipped with these devices and to be able to recognize them.

1.7 - LASERFLASH

A smokeless, red flash from a device is a clue that it is an LRF/D is using a ruby laser. However, some lasers use invisible infrared light. Therefore, lack of a visible flash from a device does not mean that it is not an LRF/D. If a crewmember detects a flash, he should not look at it without laser-filtering protection.

1.8 - EMPLOYMENT

Sometimes an LRF/D can be identified by the way it is being employed, especially if it is used with a missile system. The way the LRF/D is handled and other specific things that occur while it is being used can help identify it.

1.9 - PROTECTIVE MEASURES AND DEVICES

Whether laser use is deliberate (enemy) or accidental (friendly), the results will be the same. If a crewmember uses an optical sight (direct-view) or scans without a laser-filtering device and laser light enters his eyes, injury will probably occur. Protective measures and devices can prevent or reduce the severity of laser injuries on the battlefield. Night vision devices, such as the AN/PVS-5 and the AN/AVS-6, and thermal-imaging systems offer complete eye protection from low-energy lasers.

1.10 - LASER LIGHT

1.10.1 - IN-BAND

Laser light, which is in-band to direct-view (400 to 700 manometers) optical devices, will pass directly through the system unaffected by the optical glass. Therefore, eyeglasses or sunglasses will not prevent eye injury from in-band lasers. Aircrews must wear specially designed protective visors on their helmets to obtain laser protection.

1.10.2 - OUT-OF-BAND

Out-of-band laser light is absorbed by the first optical source in the optical train. Thus, aircrews wearing eyeglasses or sunglasses or looking through any optical device will be somewhat protected from eye injury. Some damage to a crewmember's cornea may occur unless he places an optical lens in front of his eye or uses a protective visor.

1.10.3 - MAGNIFYING OPTICS

Since direct-view magnifying devices increase the severity of eye injury from lasers, aircrews should use magnifying optical devices only when necessary for critical tasks such as threat identification. In a known or suspected laser environment, indirect-view-magnifying devices, such as the FLIR or the TADS operated in the day television mode, will protect the observer from eye injury.

1.11 - LASER FILTERS

Filters can stop laser light. A good laser filter will absorb or reflect more than 99 percent of the laser light for which it is designed. A laser filter must allow all other colors to pass through except those that it protects against. Therefore, a laser filter is useful only against those lasers for which it is designed. The filters may be built into the equipment or come as clip-on additions to the eyepiece.

1.12 - ELECTRO-OPTICAL WARNING SYSTEM

The AN/AVR-2 laser-warning receiver will warn aircrews against laser-equipped threat weapon systems. The AN/AVR-2 will identify the quadrant from which the threat laser range finder is lasing the aircraft.

1.13 - ACTIVE COUNTERMEASURES

Some tactical expedient protective measures will be effective against laser exposure. However, they may give aircrews a false sense of security in the wrong circumstances. They may also increase vulnerability to lethal weapon fire. Some expedients that reduce vulnerability and probability of injury are detection avoidance, observation techniques, and smoke (obscurants). Counterfires can cause defeat of laser threat both before and after detection.

1.14 - DETECTION AVOIDANCE

Detection avoidance measures follow the rule of "what can be seen can be hit." Detection avoidance techniques maximize the benefits of terrain features for available cover and concealment. The masking provided by terrain and vegetation can prevent detection by Threat laser devices. The cardinal rules for detection avoidance are given in TC 1-201.

1.15 - OBSERVATION TECHNIQUES

If aircrews detect the use of lasers, they should not observe the area unless all crewmembers use protective devices. These devices include laser protective visors or indirect-view observation devices.

1.16 - SMOKE (OBSCURANTS)

Smoke or thick, naturally occurring obscurants can block visible and near-infrared lasers. Some weather conditions can reduce the effectiveness of laser weapons or prevent their use altogether. Weather conditions, such as clouds, fog, rain, and snow, affect the electro-optical characteristics of the target. Vehicle- and artillery-deployed smoke can help absorb or block out laser energy. Even with an intense amount of smoke protection, some lasers are powerful enough to penetrate through the smoke and cause eye damage.

1.17 - COUNTERFIRES

- The sensitive and fragile sophisticated subsystems of laser weapons make them highly susceptible to damage from both hostile fires and movement. A "hard kill" from indirect fire is not necessarily required to defeat a laser weapon. Vibration from explosions may possibly cause an optical system to become misaligned and thus useless. Vibration associated with high speed crossing of rough terrain could damage the optical train and cause breakdown.
- Thus, diversionary tactics to keep Threat lasers moving from place to place on the battlefield may be effective. Artillery fire is an effective countermeasure to lasers. It creates a dust cloud around the laser vehicle and contaminates or shatters mirrors, limiting the effectiveness of the laser beam.
- Another weakness of a laser weapon is the fragile exit window or mirror for the laser. Breaking this window with small-arms fire, flechette or fragmentation artillery munitions, could render the laser ineffective. The window or mirror must be kept clean to transmit the laser beam outward. Any dirt or film attached to the window or mirror would absorb the energy instead of transmitting it.

1.18 - POSITIVE UNIT TRAINING.

1.18.1 - LEADERSHIP

Good leadership can prevent panic. Positive training before battle, setting an example during laser encounters, and knowing what to do are critical. Stress in eye-injured soldiers can best be treated by leader example. Fear of blindness will be a natural response. Increased knowledge of lasers will help build the soldiers' confidence and offset their fear about lasers. Commanders should include laser avoidance and reaction methods in unit SOPS.

1.18.2 - LASER MISINFORMATION

The most serious obstacle to training and operating effectively on the directed energy weapon battlefield is the false impression many people have about lasers. Science fiction and sensational press are prime sources of misleading information about lasers. Unit training efforts should focus on common misconceptions and replace them with truths about lasers.

1.18.3 - BASIC LASER RISKS

Aviation personnel must be made aware of basic laser risks. Aircrews and aviation support personnel must be informed about the risks associated with the operation of aircraft laser equipment. Aircrews should be cautioned about the type and extent of injuries that can occur in and around areas where laser range finders/designators are operated. They must also be informed about the dangers associated with the deliberate ranging of friendly aircraft, vehicles, and personnel. A laser beam focused near or on the aircrew's faces or optics or even on the side of a vehicle may allow laser energy to penetrate the unfiltered magnifying optics. Crew members not using filter protection devices may sustain serious eye injury.

1.18.4 - PROTECTIVE MEASURES

Aviation unit training must emphasize aircrew use of the aviator's helmet laser visor when aircrews perform missions in an anticipated or a known laser environment. To reduce the chances of laser injury, aviation support personnel must be trained to wear laser protective spectacles when performing aviation ground support functions.

1.18.5 - LASER HAZARD REACTIONS

- Aviation units SOPs must include the tactical reactions expected of unit personnel if laser hazards are encountered. Some guidelines to consider when developing a laser SOP are discussed below.
- If the laser spot is nearby but not on you, the laser may look like a single bright, pure-colored flash or a series of flashes.
- If you detect a laser beam while at the flight controls, close your eyes momentarily if it will not jeopardize the immediate safety of your aircraft and crew. Turn your head away or maneuver the aircraft to avoid viewing the laser directly. As soon as possible, use the protective visor or spectacles, submit the appropriate report, and continue the mission.
- If you detect a laser beam while not at the flight controls, momentarily close your eyes or look away from the laser. Use the protective visor or spectacles and take the flight controls if required. Assist the pilot in command as necessary in submitting the appropriate report and accomplishing the mission.
- If you experience a sudden blurring of vision or a feeling like sand in your eye, you may have been hit with an infrared laser. In extreme cases, sudden pain and loss of vision may

occur. (You will not be forewarned because humans cannot see infrared laser light.) Pain or the inability to see may require the immediate transfer of the flight controls. The injury may be so severe that medical aid is required before continuation of the mission.

1.19 - FIRSTAID

- Unit training should include first aid training for laser casualties. Aviation missions are frequently conducted in remote areas where medical assistance is not readily available. Therefore, crewmembers should be trained in the treatment of laser injuries. FM 8-50 discusses first aid for laser casualties in detail.
- Flash Blindness. Flash-blinded crewmembers will recover in a matter of seconds to minutes if no other injury is present.
- Minimal Retinal Burns. Some disorientation and loss of fine vision may result from minimal burns. A crewmember suffering from these injuries should not be assigned tasks that require fine visual acuity until his vision clears.
- Injury. If a crewmember is seriously injured, the crew may proceed to a medical treatment facility if the mission allows. If the crewmember can function (single eye injury and no shock or panic) and another crewmember can assume aircraft control, then the crew should continue the mission. Uninjured crewmembers should watch injured crewmembers for signs of shock.